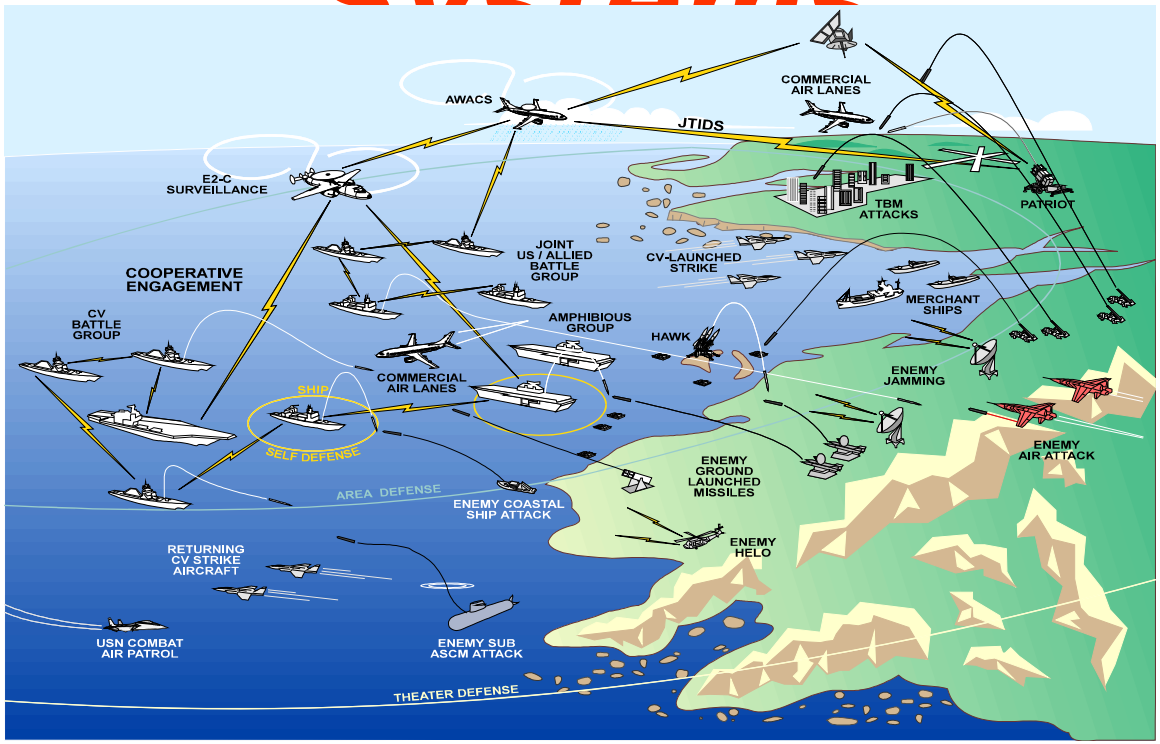
Evolutionary Acquisition of DoD Systems



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Workshop Outline

- Overview and Definitions
- Changes in Requirements Generation and Acquisition
- EA and Systems Engineering
- Architectures
- Open Systems
- Assessing Technology Readiness
- Technology Cycles
- Risk Management/Mitigation
- Metrics
- Cost Estimating
- Applying Evolutionary Acquisition
- AT&L Knowledge Management

Relationship of EA to SD and ID

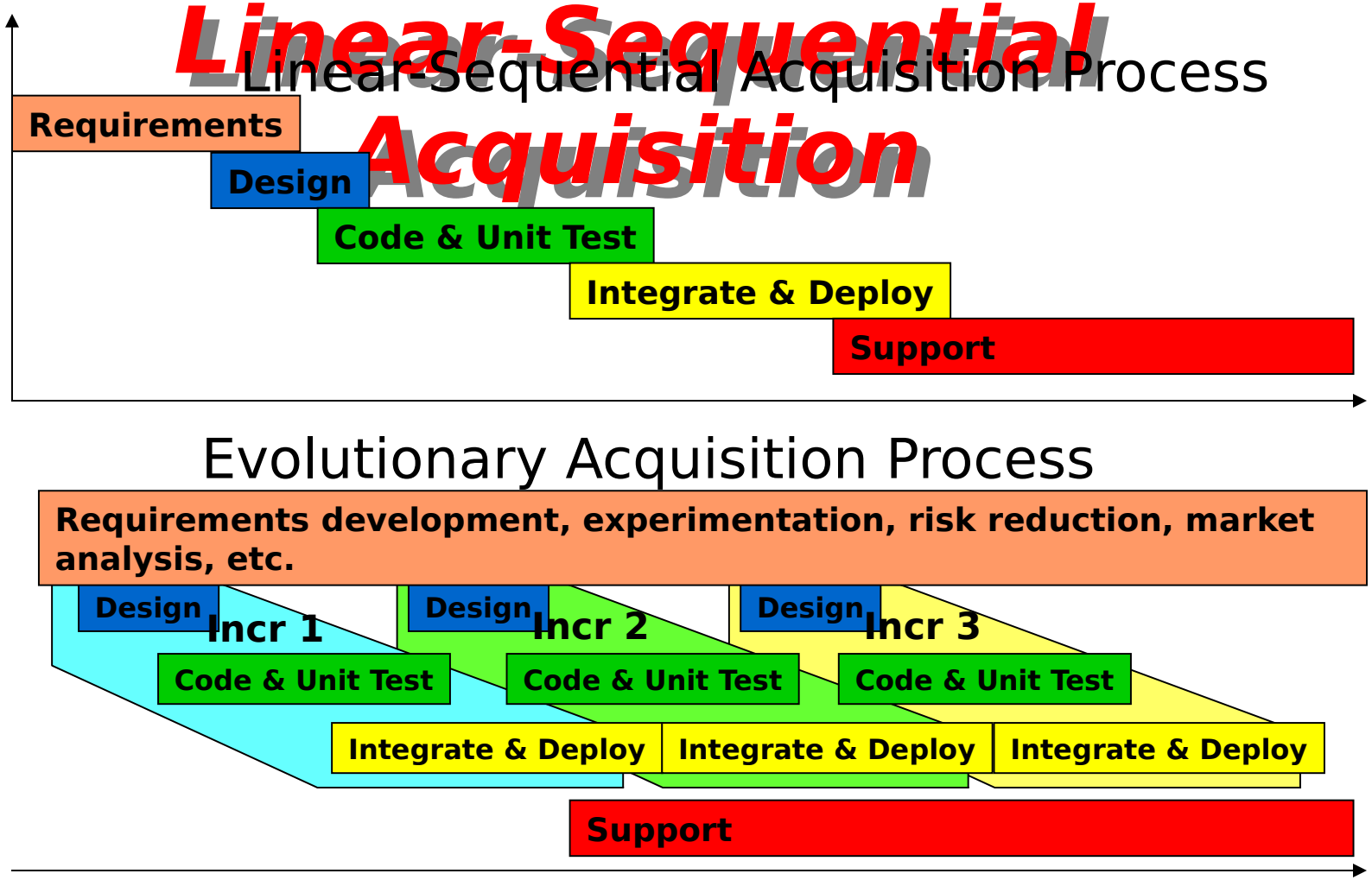
- Evolutionary Acquisition is an *acquisition strategy*
- Spiral Development and Incremental Development are *development processes* or *methodologies* in which a product is developed and acquired in increments vice the complete system.
  - Which process is used depends on whether the requirements are known up front.

DoD Acquisition Policy

Evolutionary acquisition is the preferred DoD strategy for rapid acquisition of mature technology for the user. An evolutionary approach delivers capability in increments, recognizing, up front, the need for future capability improvements. The objective is to balance needs and available capability with resources, and to put capability into the hands of the user quickly. The success of the strategy depends on consistent and continuous definition of require-ments, and the maturation of technologies that lead to disciplined development and production of systems that provide increasing capability towards a materiel concept.

DOD Instruction 5000.2 (signed May 12, 2003)

Evolutionary Acquisition versus Linear-Sequential Acquisition



Evolutionary Acquisition Characteristics

- General description of desired full system functional capability
- Concise statement of full system operational concepts
- Flexible overall architecture allowing incremental design
  - Use of Open Systems Architecture is one method
- Plan to incrementally achieve desired total capability
- Early definition, funding, development, testing, supporting and operational evaluation of initial increment of operational capability
- Continual dialogue and feedback among users, developers,

Incremental Development

- Incremental Development (ID) definition
  - In this process, a desired capability is identified, **an end-state requirement is known**, and that requirement is met over time by development of several increments, each dependent on available mature technology.

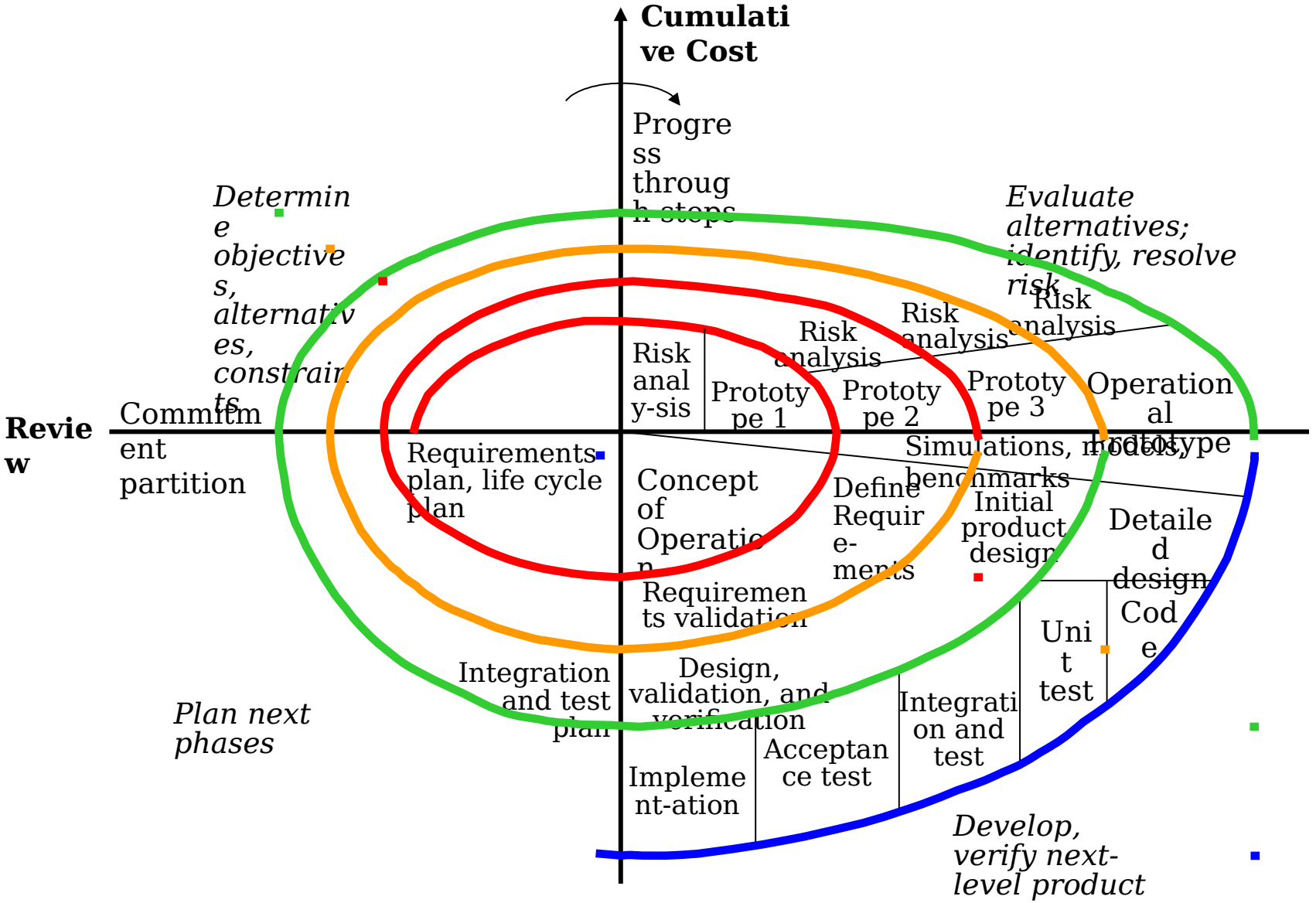
[Emphasis added]

DoD Instruction 5000.2 *dated May 12, 2003.*

Incremental Development

- F/A-18 E/F Super Hornet
  - Low Risk Approach
    - Immature technologies deferred to later increments
  - Allowed earlier delivery of initial system
  - P3I Improvements
    - Advanced Tactical FLIR
    - Active Electronically Scanned Radar
    - Helmet Mounted Cueing System
    - Engines Upgrade
    - Integrated Defense Electronic Countermeasures

Spiral Development Model*



*Reference: "The Spiral Model as a Tool for Evolutionary Acquisition" Crosstalk -The Journal of Defense Software Engineering, May 2001; Dr. Barry Boehm

Spiral Development

- Spiral Development (SD) definition
  - In this process, a desired capability is identified, but **the end-state requirements are not known at program initiation**. Those requirements are refined through demonstration and risk management; there is continuous user feedback; and each increment provides the user the best possible capability. The requirements for future increments depend on feedback from users and technology maturation.

[Emphasis added]

DoD Instruction 5000.2 *dated May 12, 2003.*

Spiral Development Example

- Predator UAV
  - Developed as an ACTD
  - Initial requirement for unmanned aircraft to provide real-time reconnaissance
  - As a result of operational use, new requirement to strike time critical targets
    - Armed with Hellfire missile
    - Can carry laser designator
  - Further improvements in work as the result of operational feedback are improved engines, sensors and increased payload
  - Lessons learned from Iraqi Freedom?

jor difference is that requirements for upgrades were generated by feedback from operational use

Advantages of Spiral Development

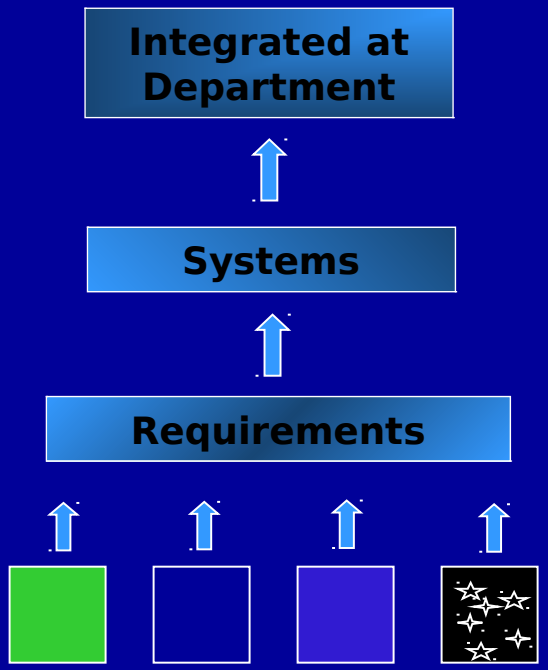
- Spiral development is designed to be more responsive to user needs
  - Shorten turn around time for emergent user needs
  - Focus on the most critical user needs at the current time
  - Avoid developing things the user may have thought they needed, but later discovered were not that critical.

Force Transformation

- Spiral Development also supports rapid development of new ways of fighting
- Current acquisition system generally develops requirements for new systems based on how we did things in the past, not how we will do things in the future
- Example
  - One part of the problems with the A-12 was the requirement to carry the entire bomb load of an A-6, the aircraft it was to replace, internal to the aircraft
  - This was based on tactics used in Vietnam and ignored the rapid emergence of precision guided weapons that were already in use at the time

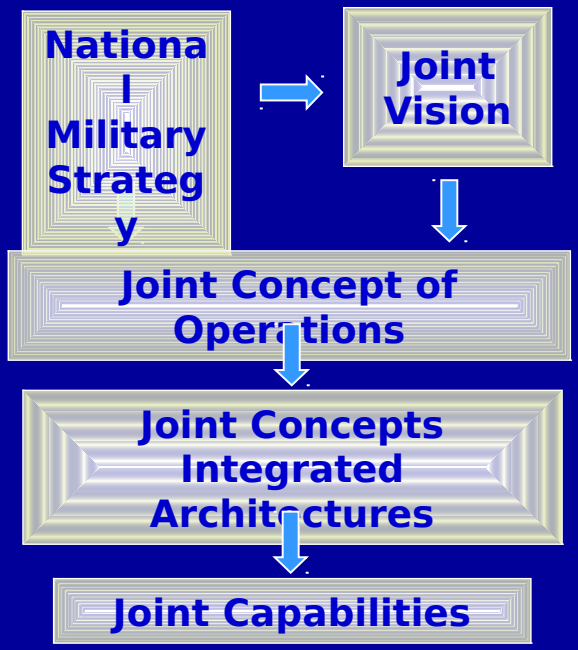
Transformation to the Joint Capabilities Integration and Development System

RGS



Bottom Up, Often Stovepiped

JCIDS



Top Down, Born Joint

Requirements & Acquisition Process

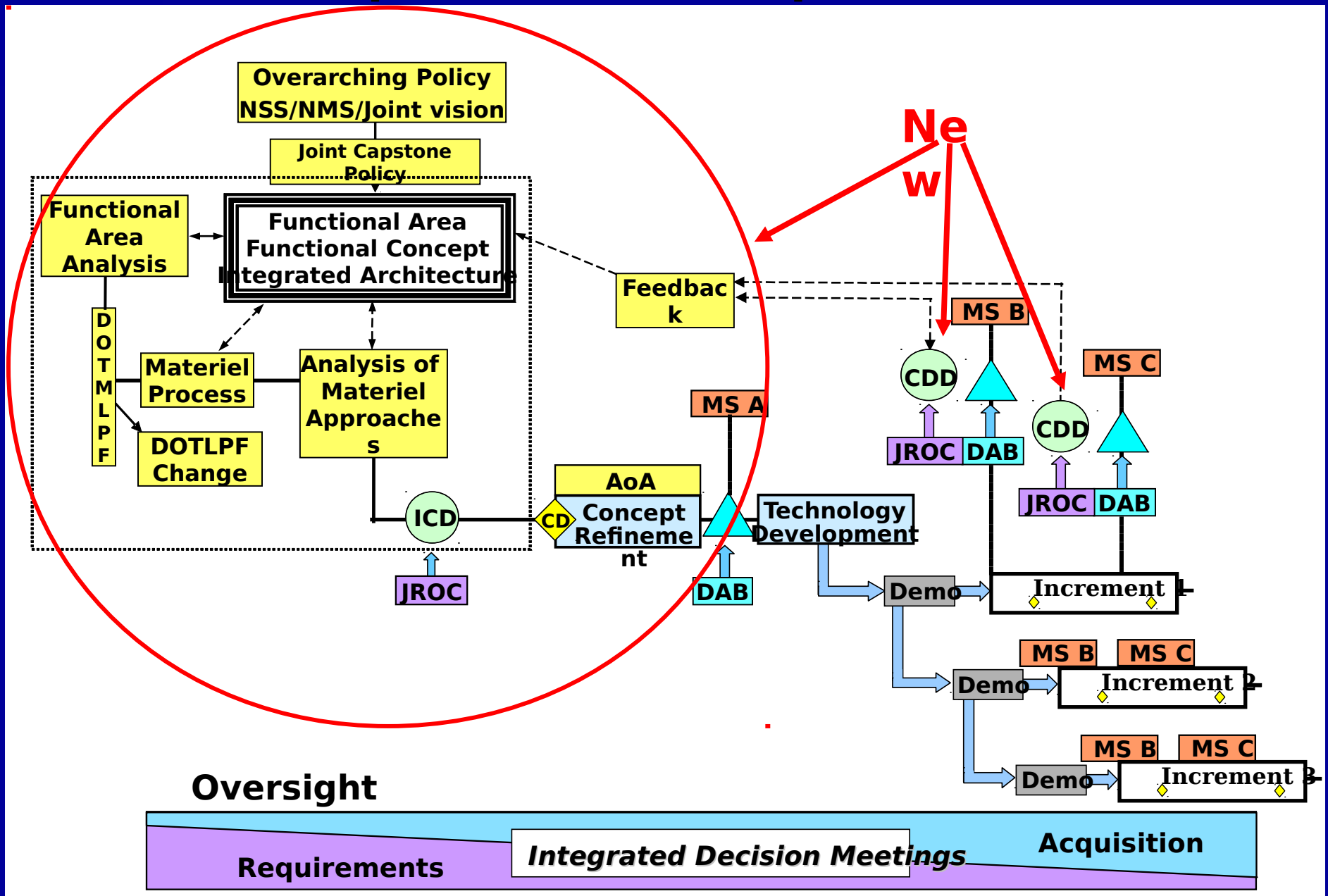
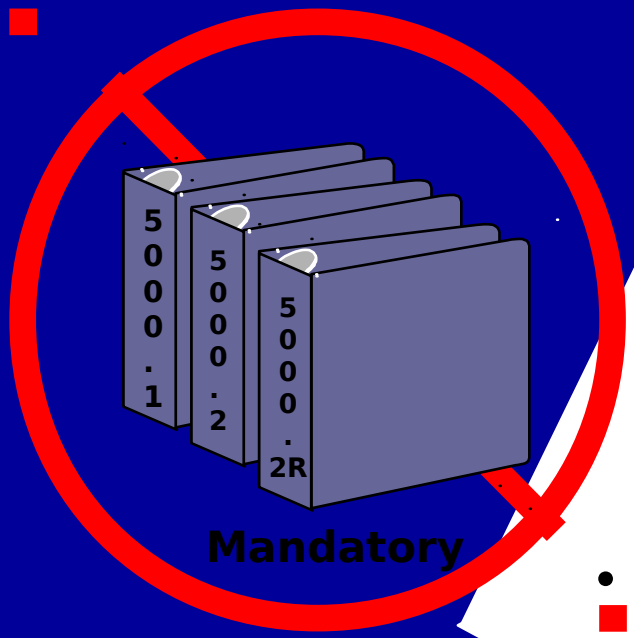


Fig. 2, DoDI 5000.2

2000 vs. 2003 Versions 5000 Series

OLD

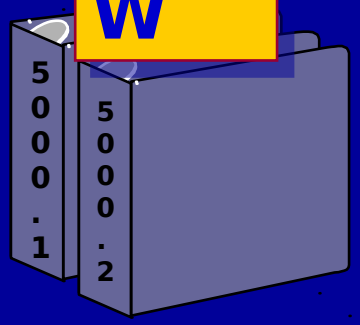


Mandatory

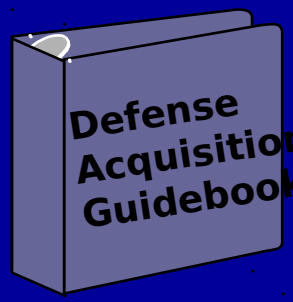
- **Guiding Principles**
- **Emphasis on Innovation**
- **Focus on Outcomes**

- **Discretionary**
  - -Best Practices
  - -Lessons Learned
  - -Expectations

NEW



Mandatory

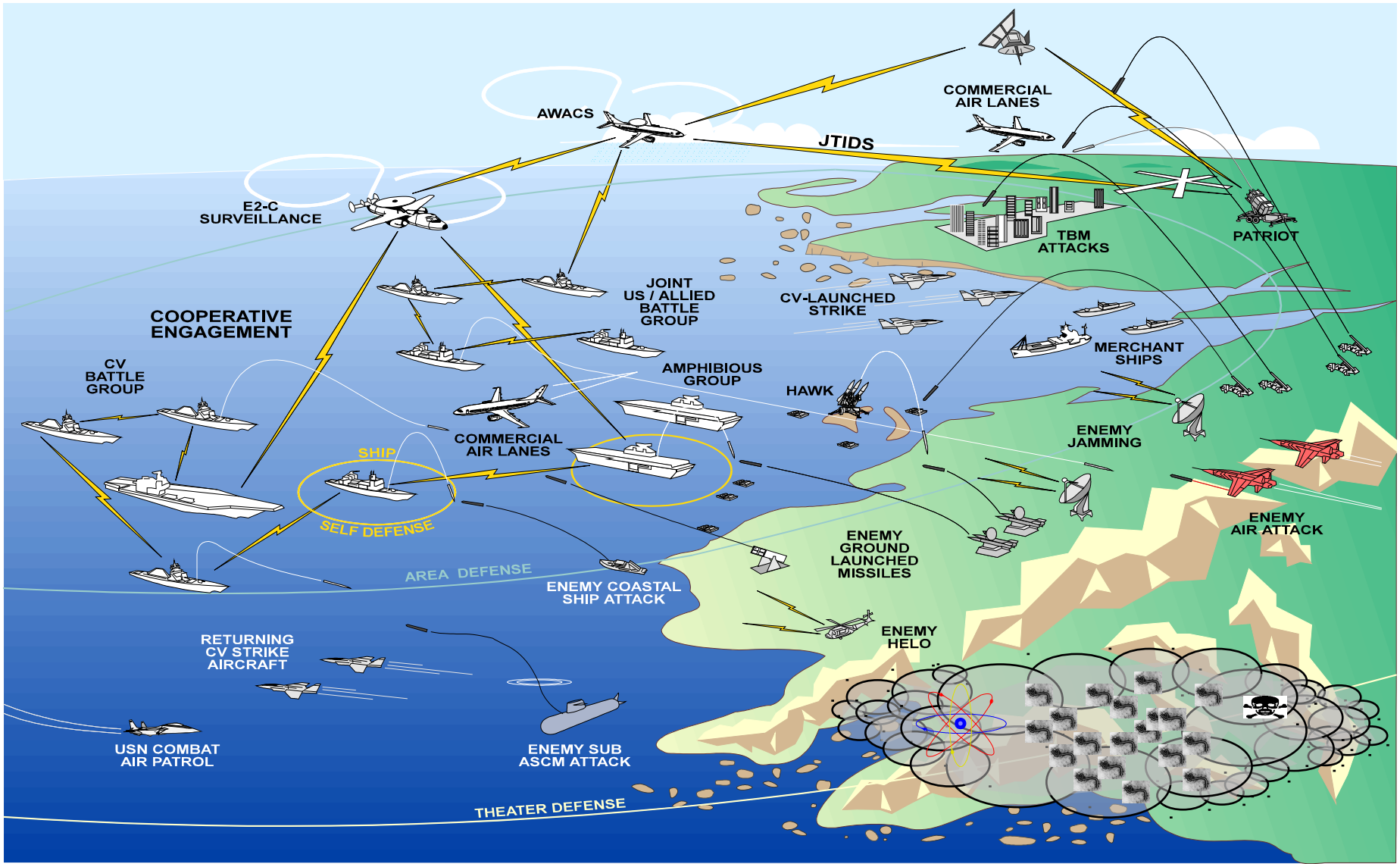


Discretionary

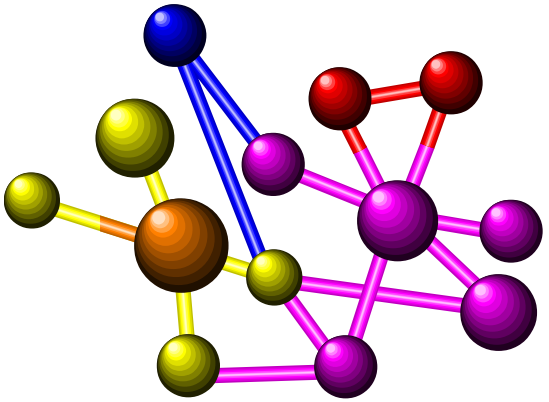
EA and Systems Engineering

- Spiral Development requires a solid systems engineering process for success
  - Requirements Development
  - Trade Studies
  - Risk Management
  - Configuration Management
  - Architecture Development
  - Interface Management

The Modern Battlespace Envir



Architecture What is it?



- **The structure of activities or components, their interrelationships, and the principles and guidelines that govern their design and evolution over time. May be logical or physical.**
- **The engineering vision that defines the engineering definitions and allocations to follow.**
- **Consists of different views of a common object or system. A single architecture has multiple views.**

Integrated Architecture: One Architecture - 3 Views

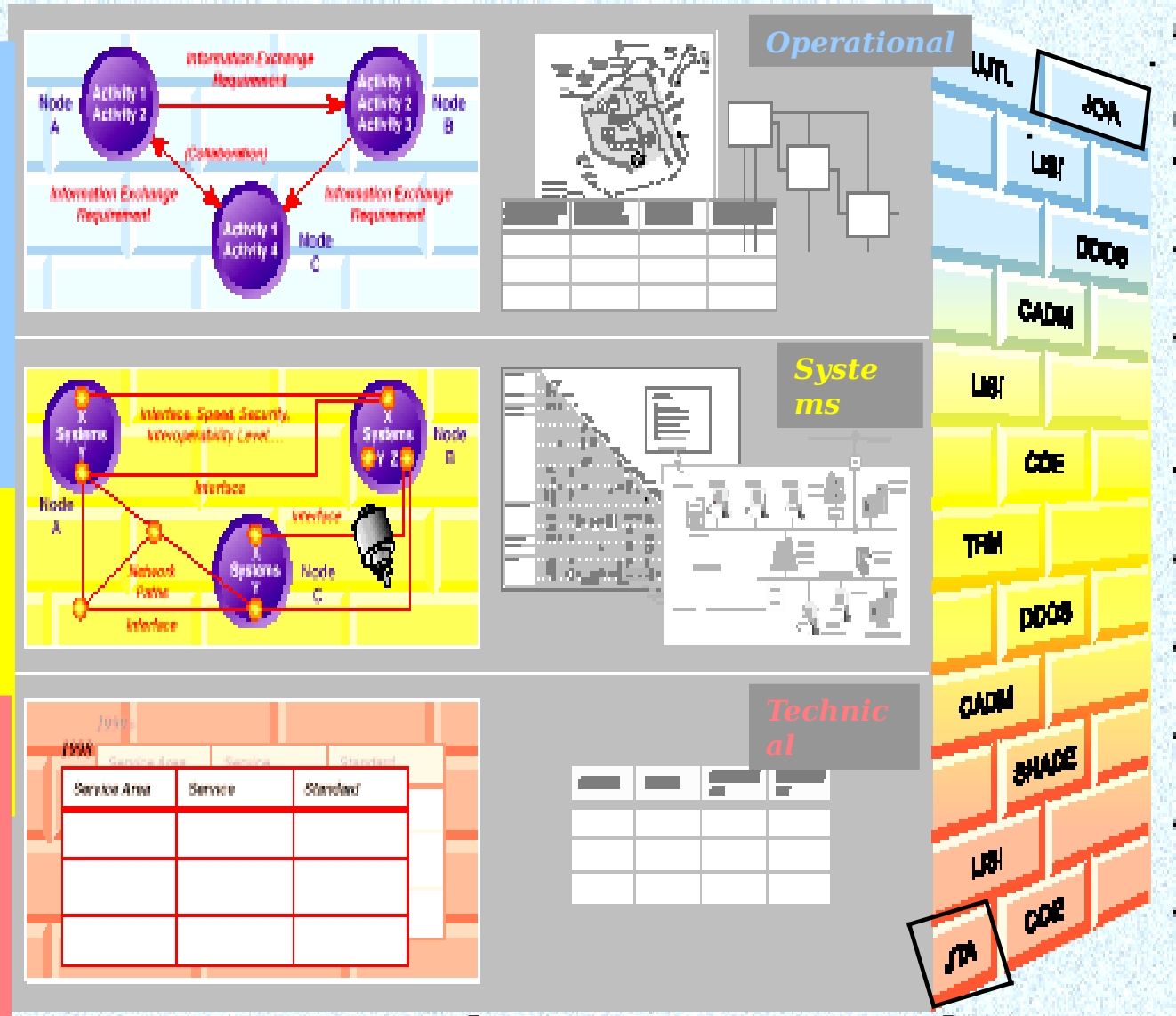
The Operational View

describes and interrelates the operational elements, tasks and activities, and information flows required to accomplish mission operations.

interrelates the existing or postulated technologies, systems, and other resources intended

The Technical View

describes the profile of rules, standards, and conventions governing systems implementation.



Source: C4ISR Architecture Framework

Design for Product Evolution

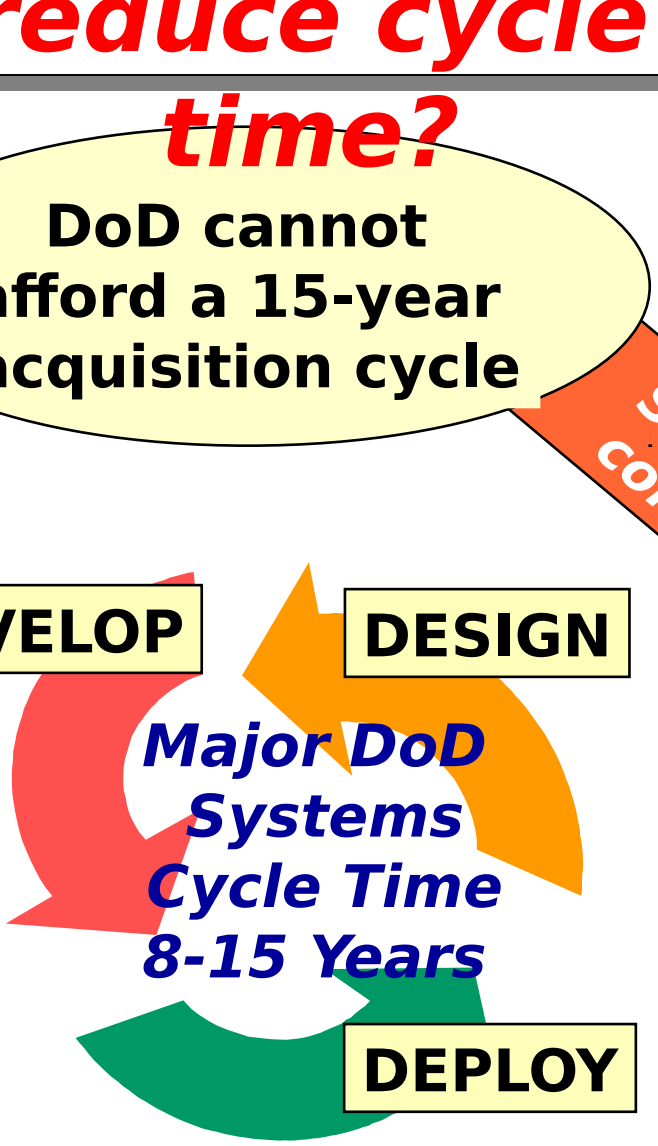
- Plan From The Beginning
- Focus: Make It Easy To Modify
- Standard Interfaces
  - Compartmentalized Design
  - Modularity
  - Recognized Interface Standards (preferably commercial)
- Standard Components
  - Increases opportunities for COTS, NDI
- Emphasize Interface Control To Provide Inherent Upgrade Capability

Attributes of an Open System

- Standards are Commonly Available
- Multiple Sources of Supply
  - Acquire building blocks from several sources on continuing basis
  - DoD is one of many customers for these building blocks
- Technology Transparency
  - Replace building blocks (HW or SW) without redesign
  - Incorporate new technology as it comes to market
- Lower life cycle cost for weapon systems
- Better performing systems with

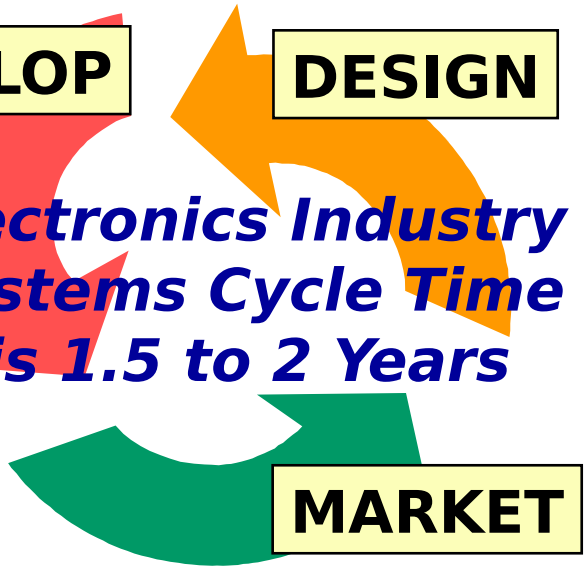
Why do we need to reduce cycle time?

DoD cannot afford a 15-year acquisition cycle



Major DoD Systems Cycle Time 8-15 Years

Supporting technology is constantly evolving



Electronics Industry Systems Cycle Time is 1.5 to 2 Years

Commercial market incorporates new technology 4 to 8 times faster

Radar Displays

Old display
welded to deck
Monochromatic
Big and heavy

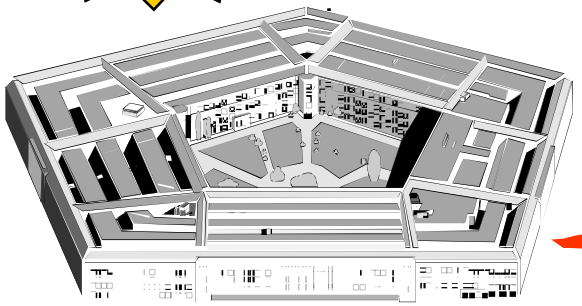
Commercial Display
Color picture
Rack mounted
Unit protection in shock mounts

Why Open Systems Are So Important

2000

DEVELOPER & USER

1950



DEVELOPER & USER

DOD no longer "drives" development. Instead, it must what industry has developed for commercial applications.

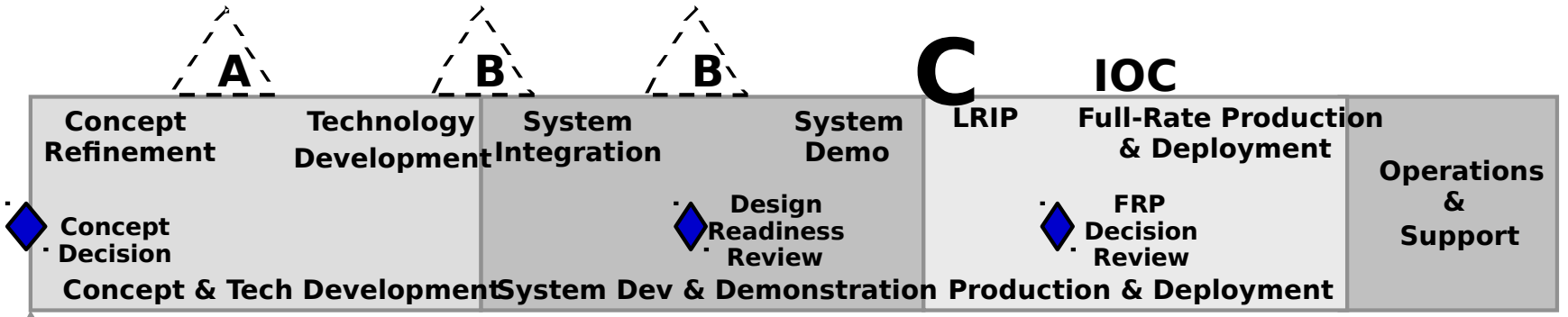
Technology Transition Program Manager's Perspective

- How mature is the technolo
- What are the risks?
- What are the payoffs?
- Cost and schedule?
- Where to enter the acquisition cycle?

Technology Insertion

Research (TRL 1) **Technology (TRL 2)**	**Remain in S&T or Concept Explora**
Proof of concept (TRL 3) **Components validated in lab (TRL 4)**	**Component Advanced Development**
Components validated in relevant environment (TRL 5)	**System Integration**
System/subsystem model demonstrated in relevant environment (TRL 6)	**System Demonstration**
System prototype demonstrated in an operational environment (TRL 7)	**Milestone C**

S&T Linkage to Defense Acquisition Proce



(1) (2) (2) (3) (3) (4)

Warfighting Needs & R&D Objectives

Systems

S&T

MDA DECISION

oversight panel

oversight panel

Adv Tech Dev (6.3)

- ACTD
- ATD
- Lab/field demo
- Warfighting Experiments

STOP

Tech Base (6.1/6.2)

- Basic Research
- Applied Research

STOP

Options

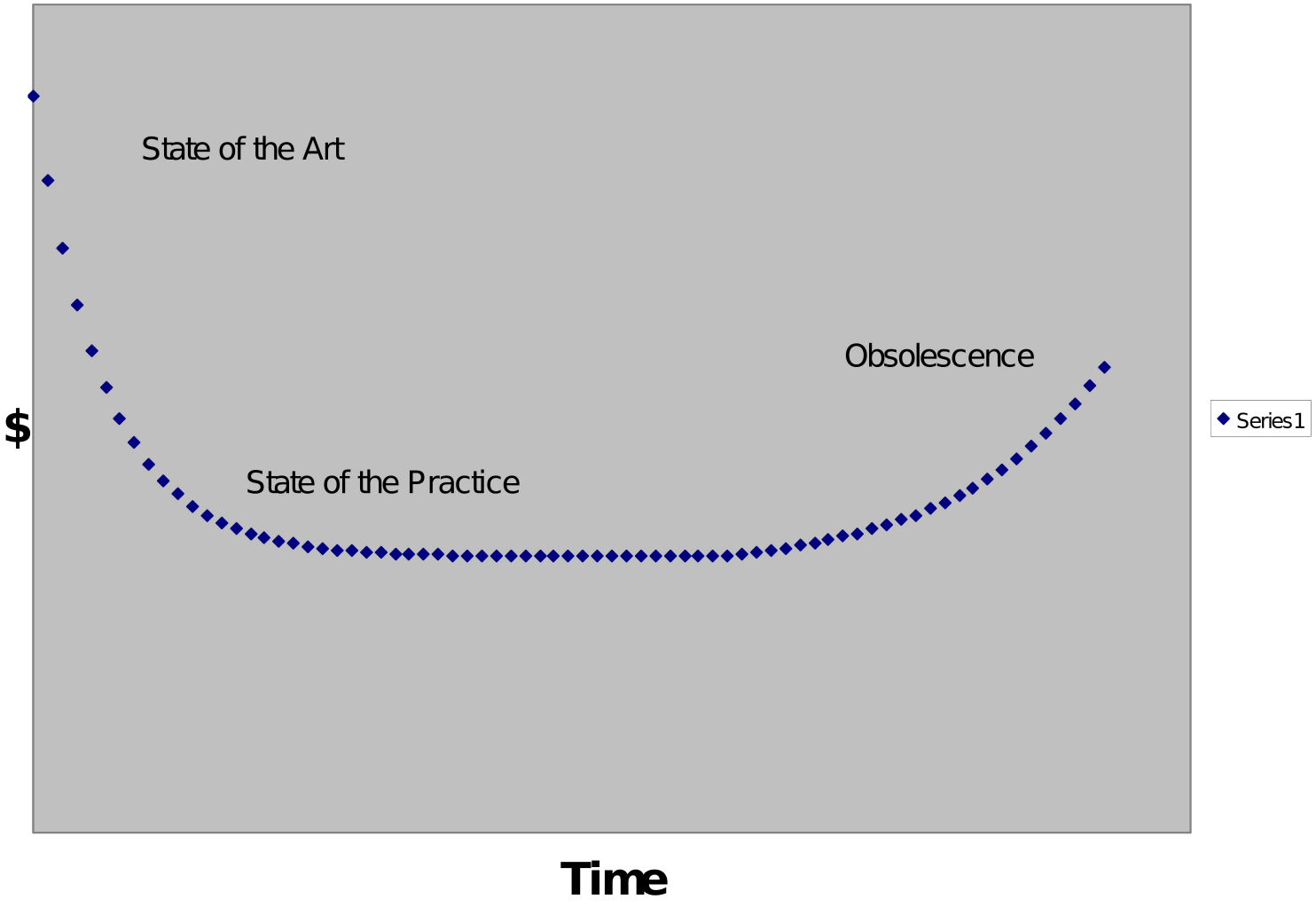
(1) Concepts for new systems/ upgrade systems out of production.

(2) Insert into ongoing systems development, or complete ACTD development.

(3) Upgrade system in production/ fielded systems or produce matur ACTD.

(4) Use of new technology for demilitarization/disposal.

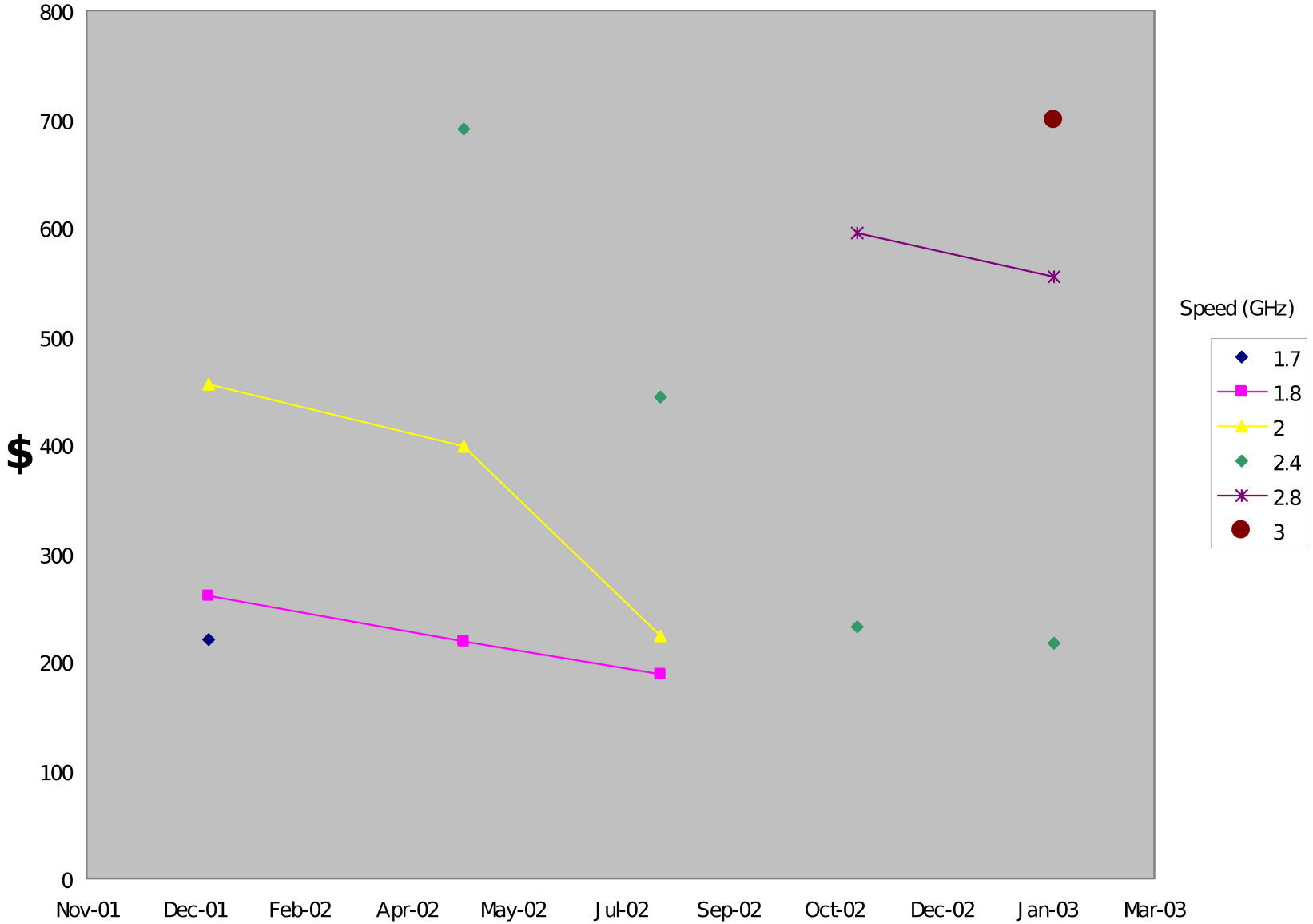
Technology Cycle



Technology Cycle

- State of the Art
  - New, cutting edge technology
  - Best Available
  - Few manufacturers in the market
  - Production processes still being worked
  - Scarcity of supply
  - High Cost
- State of the Practice
  - Mature technology
  - Multiple manufacturers
  - Production learned out
  - Lean manufacturing implemented
  - Plentiful Supply
  - Low Cost
- Obsolescence
  - Old technology
  - Major manufacturers leave the market
  - Niche suppliers move in
  - Manufacturing in small batches
  - Quantities more difficult to find with time
  - Higher costs

CPU Prices


800
700
600
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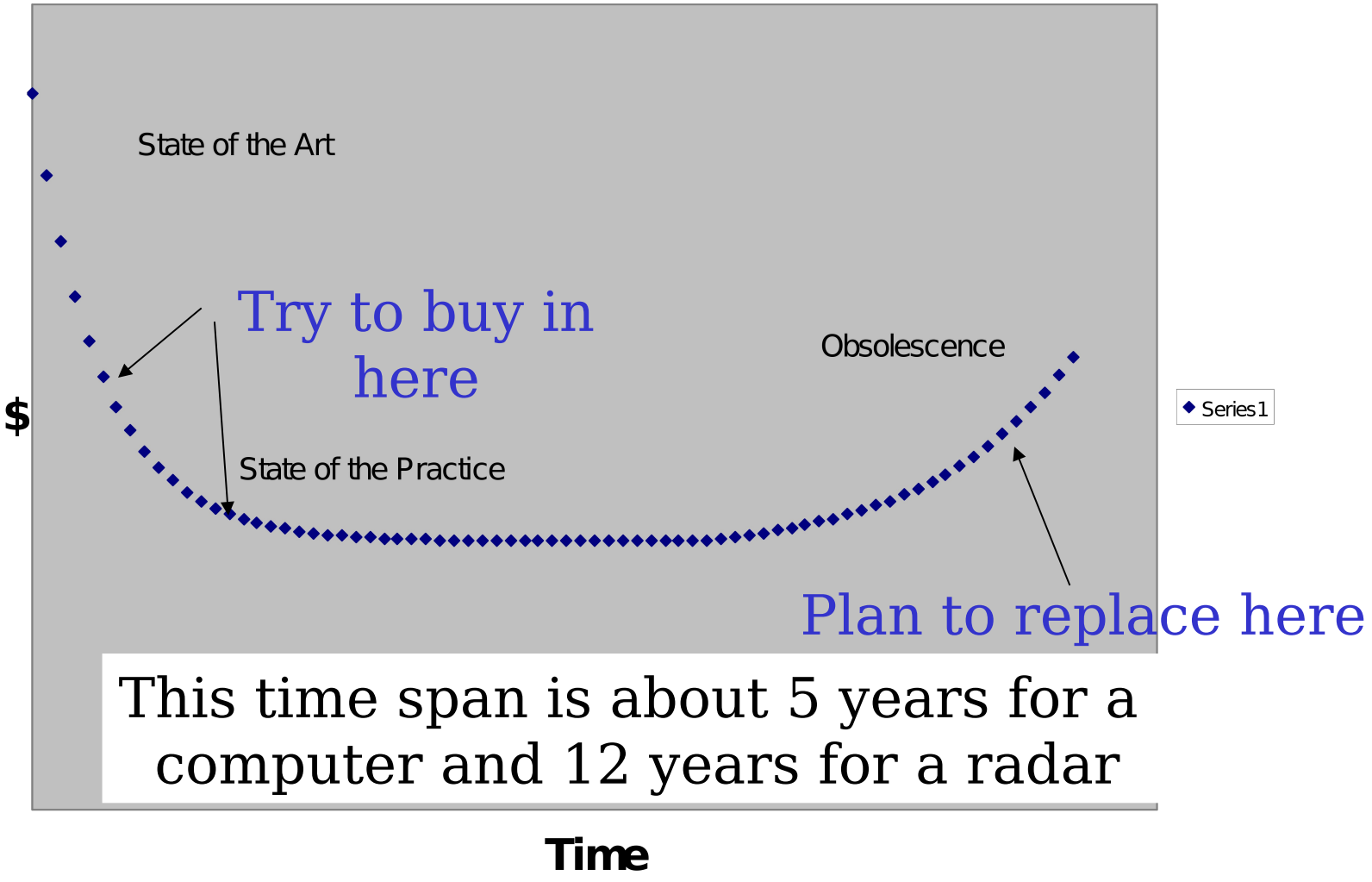
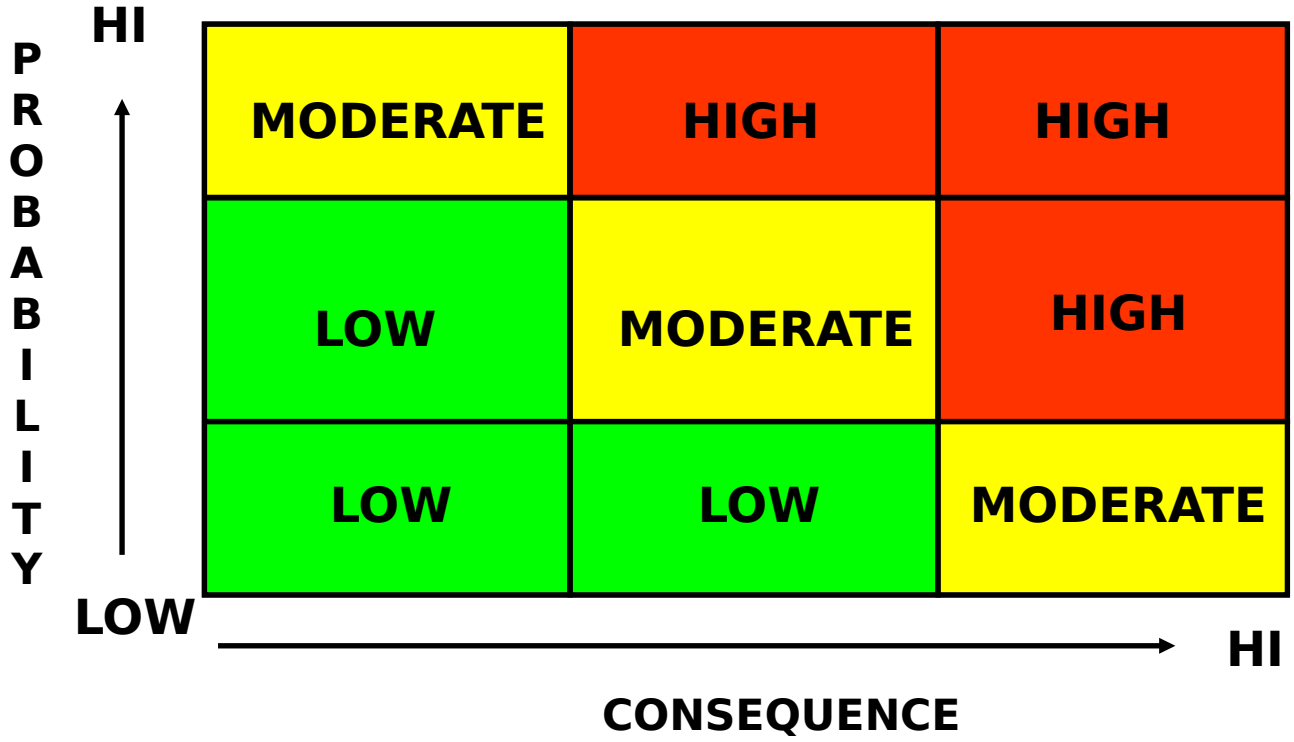
300
200
100
0
$
Nov-01
Dec-01
Feb-02
Apr-02
May-02
Jul-02
Sep-02
Oct-02
Dec-02
Jan-03
Mar-03
Speed (GHz)
1.7
1.8
2
2.4
2.8
3

Technology Refreshment



Determining Technology Risk

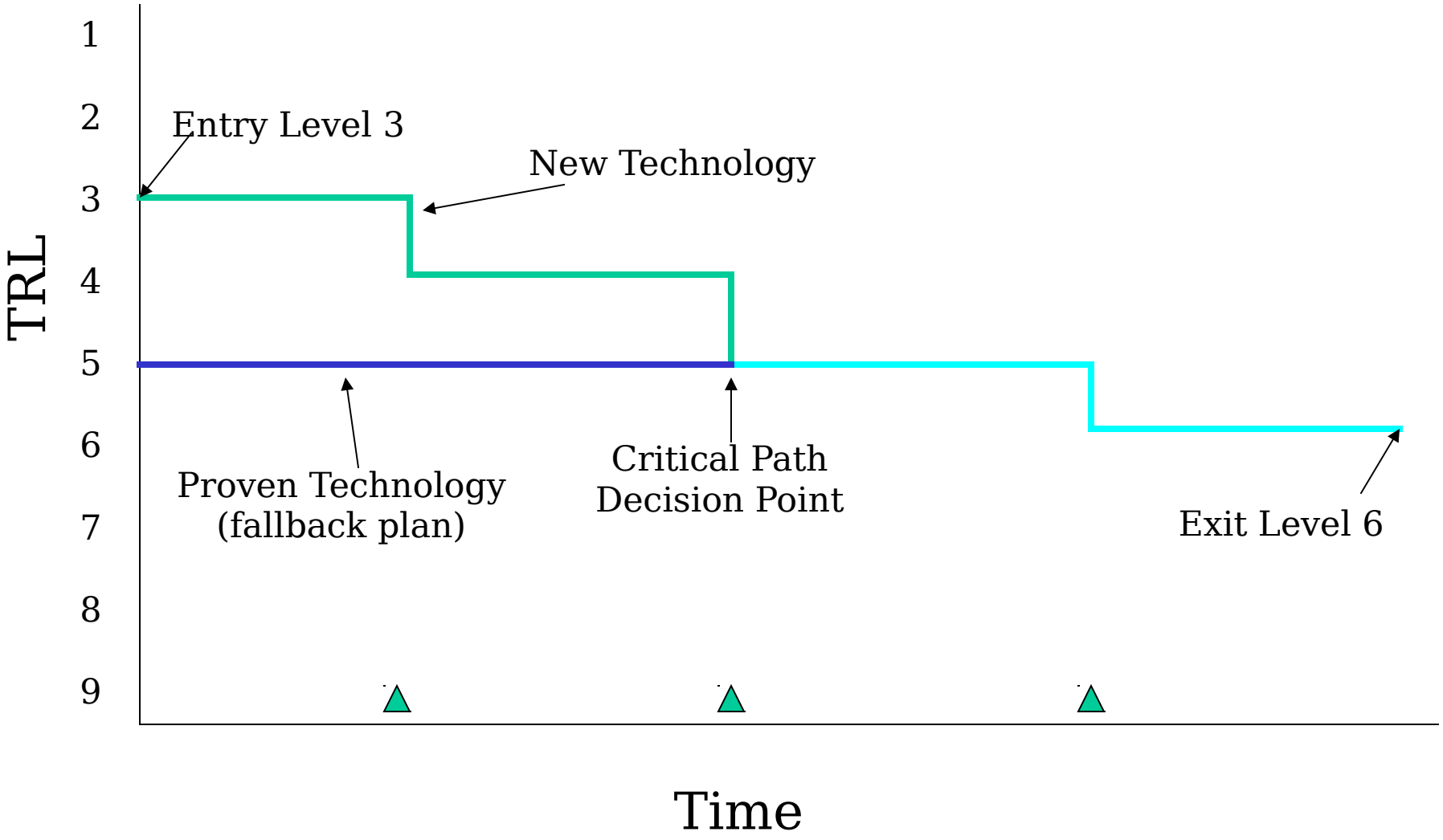


Technology risk is a function of the probability that a t
will not deliver its expected benefit and the consequer
system of not achieving that benefit

Risk Mitigation

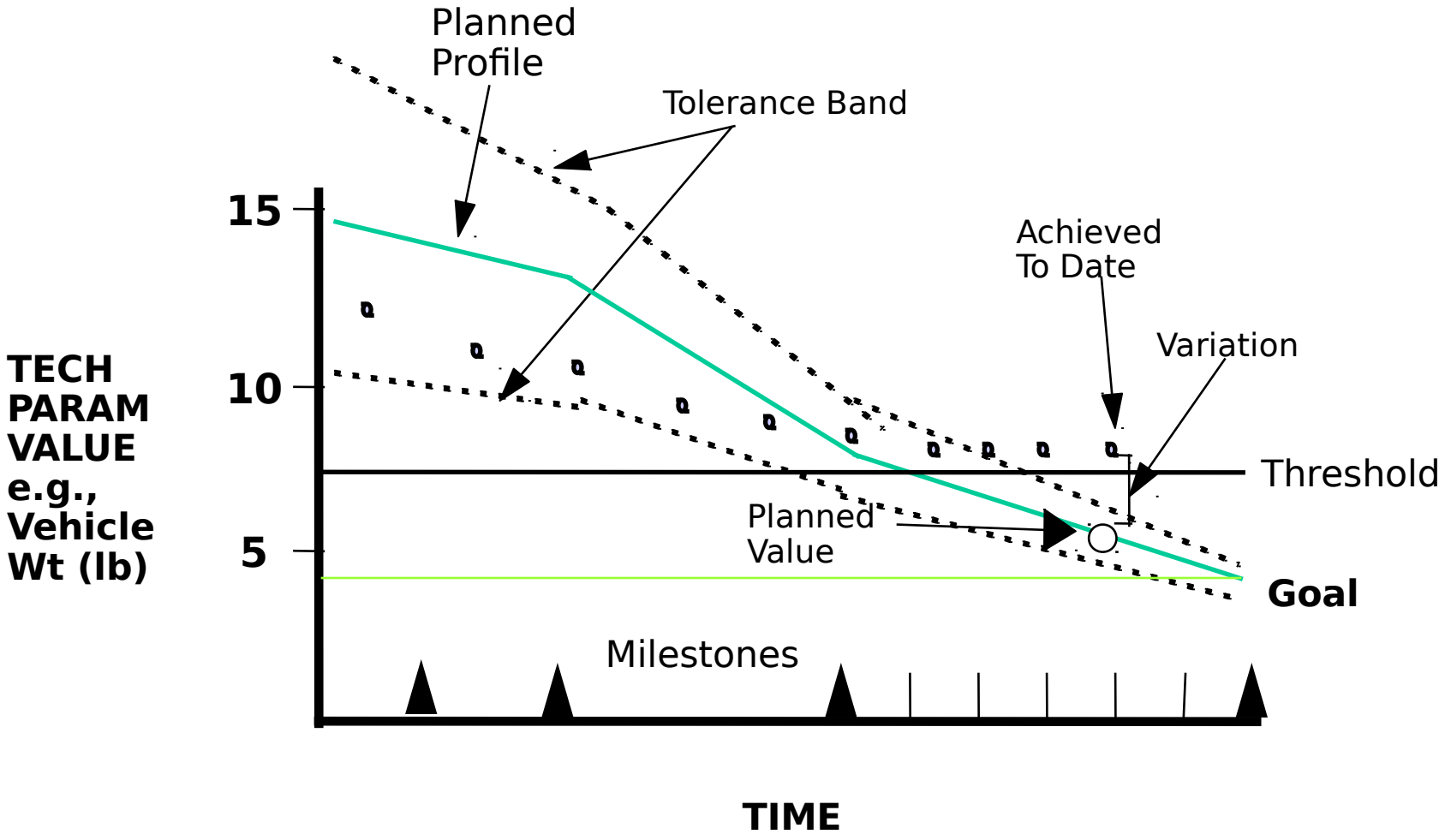
- Can Take Many Forms
  - Budget Reserves for unplanned activities
  - Concurrent Design Techniques
  - Solid technical management (TPMs, EVM, CM, Tech Reviews, etc.)
  - Integrated Tools, Automated Tools
  - Balanced Designs - Cost, performance, supportability, producibility trades
  - Disciplined Systems Engineering application
  - Bottoms Up Testing

Technology Risk Reduction Plan

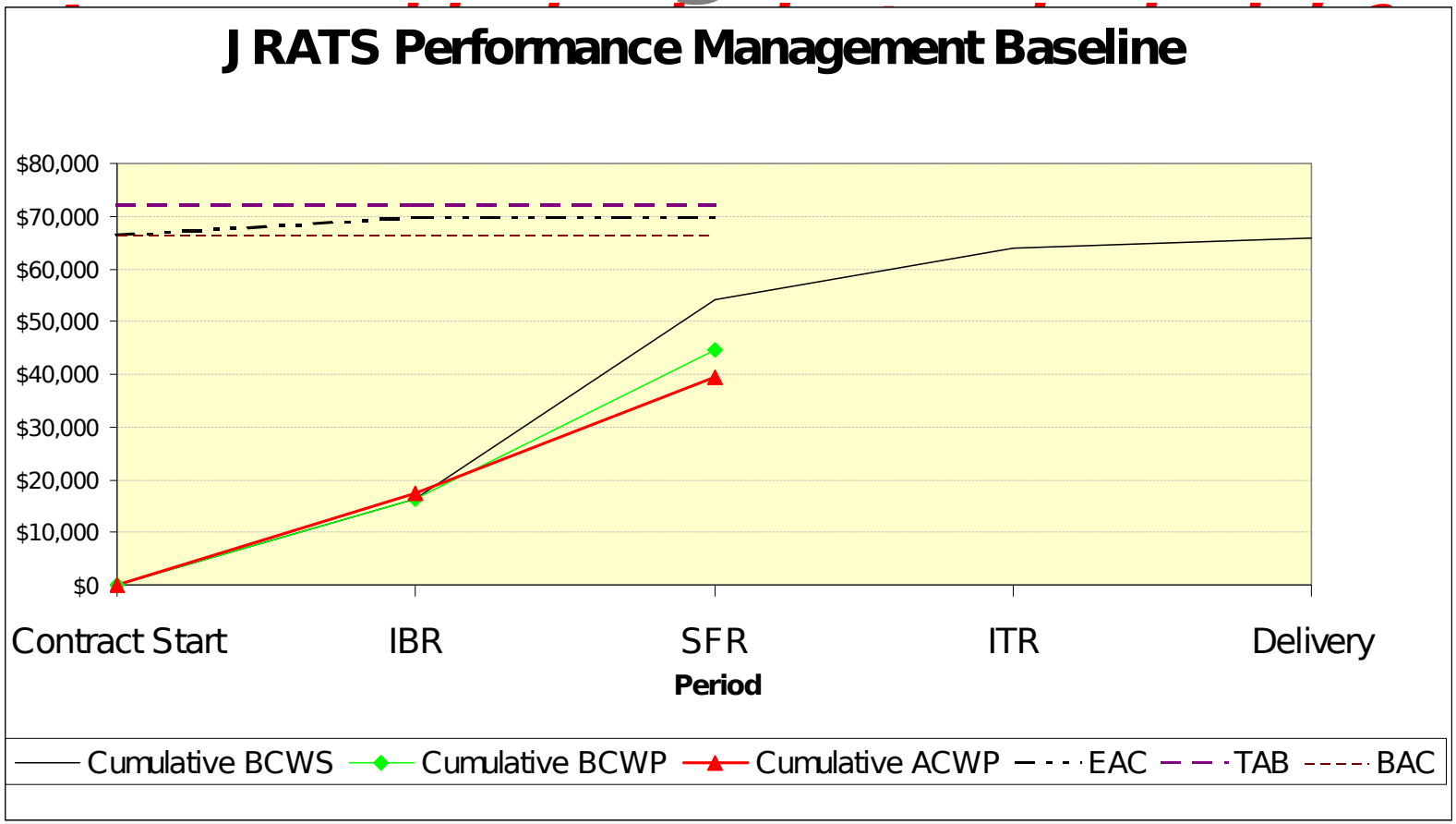


Technical Performance Measurements

Are you achieving performance on schedule?



Earned Value Management



Cost Challenges

- Cost Estimation
  - Difficult to estimate the cost when requirements and technologies are evolving
  - How much will the full capability cost?
  - Color of money
    - Parts of the system may be in development, production, operations and support simultaneously
- Funding stability
  - Commitment to follow-on blocks
- Full funding policy

Cuts in VA-class R&D pay for multiyear EOQs

NG CITES PROGRESS IN BLOCK BUY TALKS, BUT DIFFERENCES REMA

Date: March 31, 2003

With less money for R&D, the spiral development of the Virginia-class program's technology would not progress as quickly, he said. Asked if the Navy would bring the R&D numbers back up, Mullen said it would evaluate the impact on the program, concurrent with a Navy-wide R&D assessment that is intended to make sure that the dollars are going to the right places.

“When you remove resources, you're going to slow down the advancement or the insertion, in this case, of the technology that you planned,” Mullen said. “[In] this budget, as in all budgets, there are very difficult tradeoffs that needed to be made.

Fundamentals of EA/SD Cost Behavior

- EA & SD do not avoid the cost of requirements and technology change over the system development cycle
- EA & SD require a substantial investment in process management, with attendant overhead costs
- EA & SD program measures may depart significantly from traditional software measures
  - Productivity measures
  - Expenditure profiles (colors of money)

Cost Implications of Spiral Development

- First, understand the expected output
  - Full-up product, or define/refine requirements
  - For both instances, effort is expended and costs are incurred for non-deliverable interim products
- Second, understand the process
  - What resources are committed to each spiral?
  - What are the exit criteria for each spiral?
  - How many iterations are expected for a given set of functionality?
- Then, tailor the estimating methodology to the product and process
  - No school book solutions--Sorry.

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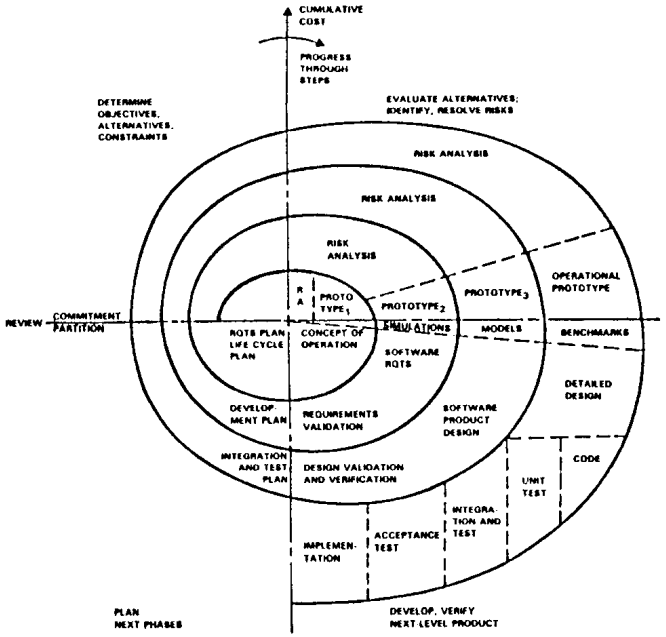
Estimating SD: Possible Approaches

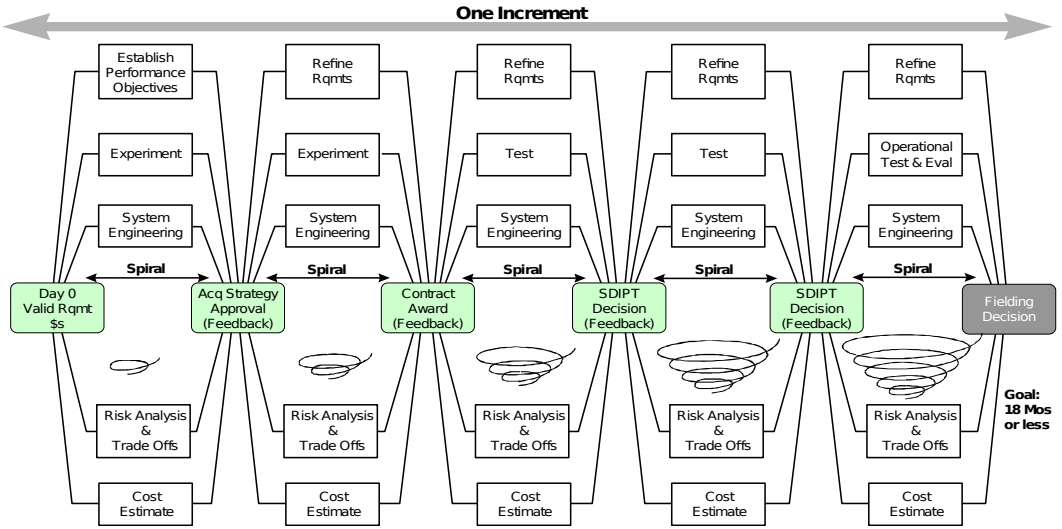
- Approach 1:
  - Start with size estimate of final delivered product; Crank in a scale factor for each spiral [e.g. Prototype LOC = DSI (0.3+0.6+0.9+1.0)],
  - Assume reuse ratios for each spiral.
- Approach 2:
  - "Unroll" the spiral (see diagram on chart 8), and estimate the effort/cost of each element and activity.
- Approach 3:
  - If SD is only used for risk reduction (no deliverable software)
  - Assume Level-of-effort (# staff months times development duration).
- Use these in combination to cross-check

Spiral Model

A: Boehm's Spiral Model



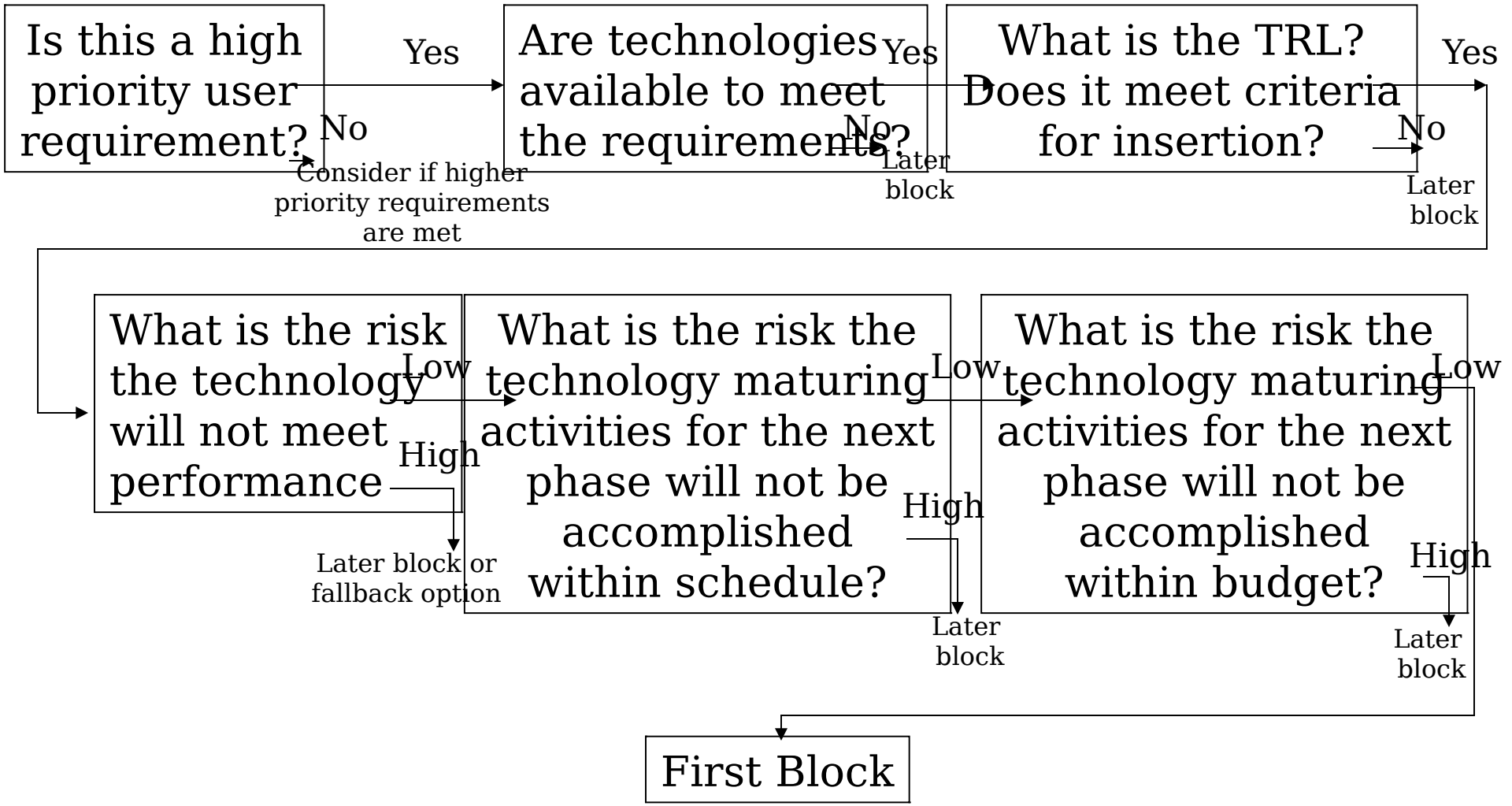
B: The "Uncoiled" Spiral



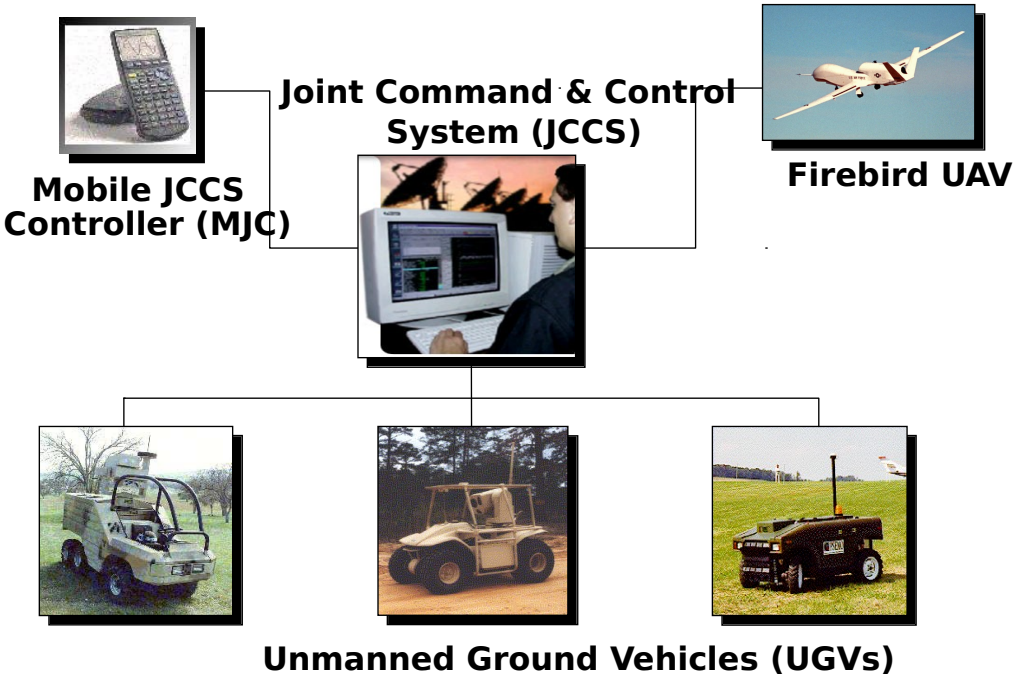
A: Boehm, B., "A Spiral Model of Software Development and Enhancement." *IEEE Computer* (May 1988): 61-

B: McNutt, R., "Reducing Air Force Acquisition Response Times: Evolutionary Acquisition and Spiral Develop U.S. Air Force Briefing, 13 Sept 2000

Building an Evolutionary Strategy



PMT-352 Spiral Development Exercise



- Future based program
- Choose from existing UGVs
- Arm for attack mission
- Technology insertion into existing systems
- Interoperable with UAV and

Joint Reconnaissance and Autonomous Targeting System

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- Program Management Communities of Practice
  - Risk Management
  - Systems Engineering
  - Contracting
  - Total Ownership Costs
- Coming Soon
  - Logistics

PM CoP

Program Management Community of Practice

Search: Go

Where the Acquisition Community Meets to Share Knowledge

What People are Saying

PM CoP Helps Multi-Billion Dollar Project
We are starting from scratch to develop a Risk Management Program for a multi-billion dollar project. Big undertaking. Lots of work. Extensively used your PM CoP website to make sure that we are not re-inventing the wheel.

In the Spotlight

The PMCoP website has changed! Many new collaboration features make it easier to use. Explore the site and tell us what you think. **Join Discussions, See Who's Online, Receive updates via email,** and more.

guest (Read)

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LOGIN

Username

Password

Join LOGIN

Watch Us Grow

2095 Members
6934 Contributions

Join PM CoP and...

- Access important Acquisition resources
- Connect with professionals in your field
- Share information and knowledge
- Collaborate in discussion areas
- Create private workspaces

Join Now »

Access Private Workspaces »

Participate in a Community

Program Management

Participate >>

The Program Management Community offers participants an executive summary of overarching important or useful Acquisition information and resources.

Contract Management

Participate >>

The Contract Management Community is structured around supporting practitioners with the contracting processes, keeping them informed of changes within the contracting field, and offering a forum for communication and collaboration.

Risk Management

Participate >>

The Risk Management Community provides a resource for job performance support structured around the Risk Management Process and offers continued collaboration and information sharing among community members.

Systems Engineering

Participate >>

The Systems Engineering Community provides guidance in requirements analysis and standardization, presents a variety of Systems Engineering specific tools, and encourages communication and collaboration among

Total Ownership Cost

Participate >>

The Total Ownership Cost Community is focused on bringing community members together by offering collaborative areas for TOC disciplines, content centered around R-TOC, and communication and interaction across all areas of TOC.

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- Contract Management(38)
- Risk Management(39)
- Systems Engineering(185)
  - Introduction(2)
  - Process(30)
  - Analysis(10)
  - Planning(9)
  - Standardization(3)
  - Evolutionary Acquisition (0)
  - Requirements(0)
  - Community Connection(7)
  - Training Center(0)
- Total Ownership Cost(9)
- Find a Member(2026)

sitemap

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Editor
- SE Editor

Systems Engineering

Systems Engineering Community

☆☆0☆☆
open topic

Features
- New! Science and Technology Management Career Field
- Probability/Consequence Software (P_CS)

NASA Systems Engineering Seminar Series

What's New
- New Version of P_CS Software Tool is now Available
- Evolutionary Acquisition Template [draft] [R-TOC Working Group]

AFRL TRL Calculator Version 1.12

The AFRL Technology Readiness Level (TRL) Calculator measures the level of technical maturity achieved by a technology using the NASA TRL scale. The calculator has separate questions to measure TRL for both Hardware and Software programs. In each category, there are two versions of the calculator. The first asks questions measuring only the technical maturity of the program, and is what we usually mean by TRL. The second adds questions that attempt to measure some program management concerns, such as Customer Focus and Program Documentation. These programmatic concerns define the Program Readiness for Transition (PRT), and usually concern only the government Program Manager (PM).

Read the Documentation

Hardware TRL Only

Software TRL Only

Hardware TRL and PRT

Software TRL and PRT

Depot System-Consequence Screening Matrix

3/7/2000

	NEGLIGIBLE	MINOR	MODERATE	SERIOUS	CRITICAL
Level 5: 91 - 100%				P11A, S11A, P21A, S21A	
Level 4: 61 - 90%			C1B, S11B, S21B	S1B, P11B, P11D, S11D, P21B	P1B
Level 3: 41 - 60%	P2A, P2B	S2A, C2A, S2B	P11C, P12A, S12A, S14A	P11G, S11G, P14A	
Level 2: 11 - 40%		S4, S11F, S12B, P24A, S24A, P24B, S24B	S11E, P11F, P12B	P11E	
Level 1: 0 - 10%		P3			

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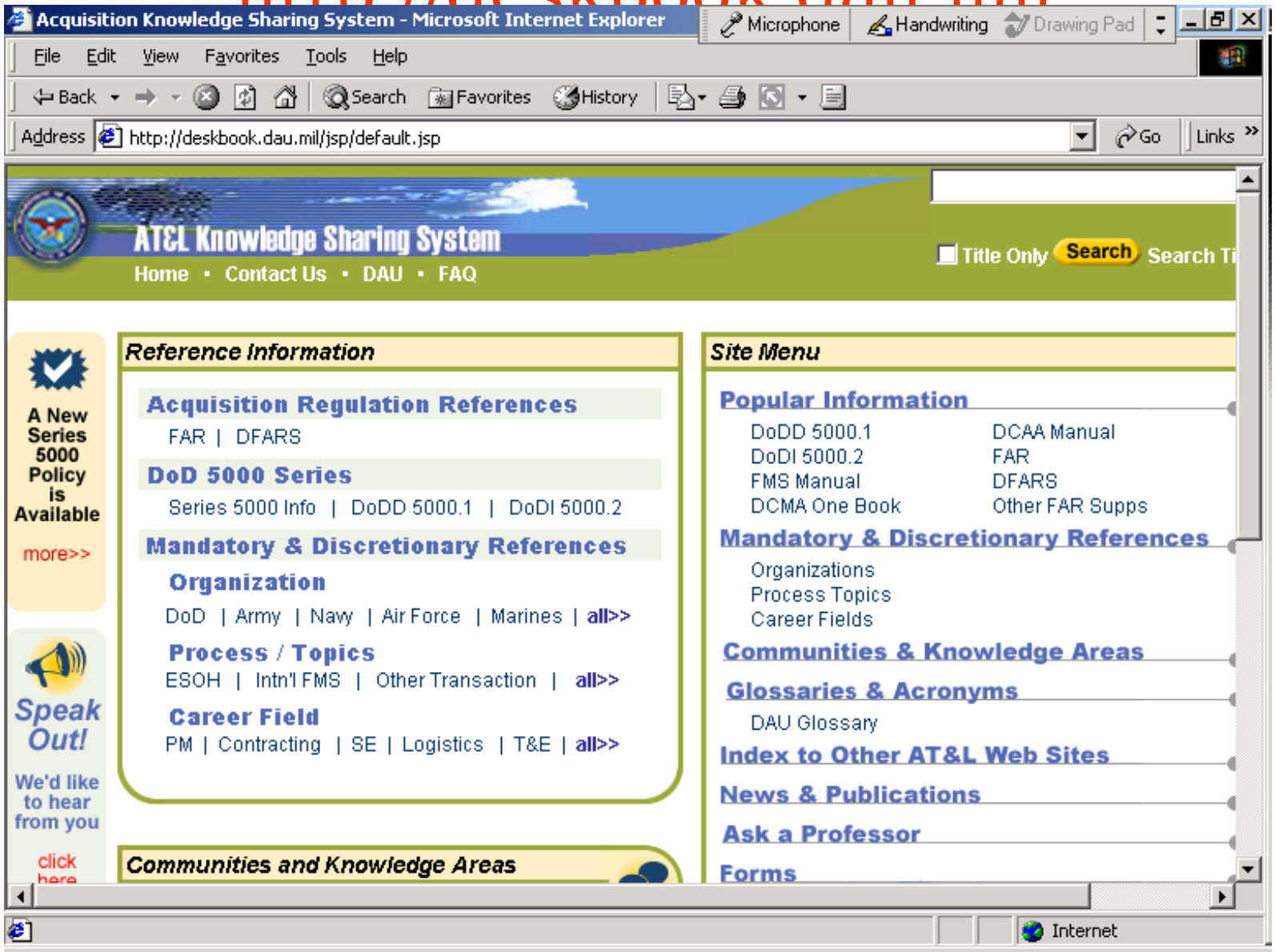
Legend

Requirements	Risks
1 RFO	1B No engineer assigned
2 Radar Receiver	2A No plan to get to QOT&E
	2B Avalibility of resources to close STR
3 Interface Blanker	
4 IFF	
11 Radar D/P	11A Non-Detects & incorrect isolation
	11B TPS not complete
	11C Lack of documentation
	11D ITA2 wiring changes
	11E SVTP
	11F Fault isolation
	11G LRU architecture does not support FI
12 A/D Converter - MSIP 038	12A SCT not complete
	12B STRs not closed
14 Radar Target DP	14A ITA migration
21 PSDP	21A Envirnomental testing of COTS monitor

New Defense Acquisition Deskbook

http://deskbook.dau.mil



Evolutionary Acquisition Summary

- Delivers initial capability to the user in a shorter time period
- Improves technology available to the user in the final product
- Cost reduction is through cost avoidance associated with poor requirements, infeasible solutions and rework
  - Up front planning and overhead management will be more
- Good Systems Engineering processes and sound technical management plans are essential for success